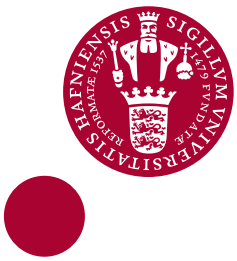

Recognising out-of-hospital cardiac arrest during emergency calls increases bystander cardiopulmonary resuscitation and survival

Viereck, Søren; Møller, Thea Palsgaard; Ersbøll, Annette Kjær; Bækgaard, Josefine Stokholm; Claesson, Andreas; Hollenberg, Jacob; Folke, Fredrik; Lippert, Freddy K

Published in:
Resuscitation

DOI:
10.1016/j.resuscitation.2017.04.006

Publication date:
2017

Document version
Publisher's PDF, also known as Version of record

Resuscitation 115 (2017) 141–147

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Recognising out-of-hospital cardiac arrest during emergency calls increases bystander cardiopulmonary resuscitation and survival☆

Søren Viereck[a,*], Thea Palsgaard Møller[a], Annette Kjær Ersbøll[b], Josefine Stokholm Bækgaard[a], Andreas Claesson[c], Jacob Hollenberg[c], Fredrik Folke[a], Freddy K. Lippert[a]

[a] Emergency Medical Services Copenhagen, University of Copenhagen, Telegrafvej 5, Building 2, 3rd Floor, DK-2750 Copenhagen, Denmark
[b] National Institute of Public Health, University of Southern Denmark, Øster Farimagsgade 5A, DK-1353 Copenhagen, Denmark
[c] Centre for Resuscitation Science, Solna, Karolinska Institute, Jägargatan 20, Plan -1, 118 83 Stockholm, Sweden

ARTICLE INFO

Article history:
Received 15 October 2016
Received in revised form 15 March 2017
Accepted 2 April 2017

Keywords:
Out-of-hospital cardiac arrest
Bystander cardiopulmonary resuscitation
Survival
Medical dispatch

ABSTRACT

Background: Initiation of early bystander cardiopulmonary resuscitation (CPR) depends on bystanders' or medical dispatchers' recognition of out-of-hospital cardiac arrest (OHCA). The primary aim of our study was to investigate if OHCA recognition during the emergency call was associated with bystander CPR, return of spontaneous circulation (ROSC), and 30-day survival. Our secondary aim was to identify patient-, setting-, and dispatcher-related predictors of OHCA recognition.

Methods: We performed an observational study of all OHCA patients' emergency calls in the Capital Region of Denmark from 01/01/2013–31/12/2013. OHCAs were collected from the Danish Cardiac Arrest Registry and the Mobile Critical Care Unit database. Emergency call recordings were identified and evaluated. Multivariable logistic regression analyses were applied to all OHCAs and witnessed OHCAs only to analyse the association between OHCA recognition and bystander CPR, ROSC, and 30-day survival. Univariable logistic regression analyses were applied to identify predictors of OHCA recognition.

Results: We included 779 emergency calls in the analyses. During the emergency calls, 70.1% (n = 534) of OHCAs were recognised; OHCA recognition was positively associated with bystander CPR (odds ratio [OR] = 7.84, 95% confidence interval [CI]: 5.10–12.05) in all OHCAs; and ROSC (OR = 1.86, 95% CI: 1.13–3.06) and 30-day survival (OR = 2.80, 95% CI: 1.58–4.96) in witnessed OHCA. Predictors of OHCA recognition were addressing breathing (OR = 1.76, 95% CI: 1.17–2.66) and callers located by the patient's side (OR = 2.16, 95% CI: 1.46–3.19).

Conclusions: Recognition of OHCA during emergency calls was positively associated with the provision of bystander CPR, ROSC, and 30-day survival in witnessed OHCA.

Introduction

Despite improvements during the past decades, overall survival after out-of-hospital cardiac arrest (OHCA) remains low [1–4]. The initial time period after collapse is critical; each moment without resuscitation, greatly decreases chance of survival [5,6]. The time from collapse to emergency medical services (EMS) arrival is often more than 5 min [4,7,8], which emphasises the critical importance of early interventions by bystanders guided by medical dispatchers.

High-quality cardiopulmonary resuscitation (CPR) and defibrillation by an automated external defibrillator (AED) prior to EMS arrival has been proven to enhance survival [3,9–16]. In recent years, focus on public access defibrillation programmes has increased, including referral of bystanders to nearby AEDs via interactive maps at the dispatch centre, and allowing professional and lay first responders equipped with AEDs to be dispatched [8,13,17,18]. Bystander CPR, use of AEDs, and public access defibrillation programmes are all dependent upon bystanders or medical dispatchers recognising OHCA [7,8]. Dispatcher-assisted CPR instructions have a positive effect on bystander CPR and patient survival [19–22]. All of this emphasises the importance of the first link in the chain of survival, as highlighted in recent guidelines [23–25].

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2017.04.006.

* Corresponding author.
E-mail address: viereck.soeren@gmail.com (S. Viereck).

http://dx.doi.org/10.1016/j.resuscitation.2017.04.006

Few smaller studies have investigated the association between OHCA recognition and survival with contradictory results [26,27]. Based on the beneficial effect of dispatcher-assisted CPR, we hypothesised that OHCA recognition during emergency calls would be positively associated with bystander CPR and survival.

The primary aim of this study was to investigate if OHCA recognition during the emergency call was associated with bystander CPR, return of spontaneous circulation (ROSC), and 30-day survival. The secondary aim was to identify patient-, setting-, and dispatcher-related predictors of OHCA recognition.

Methods

Study design and setting

This observational study was conducted in the Capital Region of Denmark, which covers Copenhagen and surrounding suburbs and has a population of approximately 1.75 million people covering an area of 2549 km^2 [28]. A single emergency phone number (1-1-2) connects the caller to a switchboard that identifies the location of the patient and the need for police, fire, or medical assistance. Medical emergency calls are transferred to the Emergency Medical Dispatch Centre (EMDC), which receives approximately 105,000 emergency calls annually [29]. Medical dispatchers are either paramedics (30%) or registered nurses with emergency care experience (70%). Dispatchers have six weeks of training in medical dispatching and use of a criteria-based dispatch tool (Danish Index for Emergency Care) [30]. When a medical dispatcher suspects an OHCA, a two-tiered system, including an ambulance and a physician-staffed Mobile Critical Care Unit (MCCU), is dispatched as a "priority A" response (with lights and sirens). The dispatcher is obliged to provide dispatcher-assisted CPR instructions. A map of publicly available AEDs is integrated into the dispatch system for the dispatcher to direct the bystander to the nearest AED [18]. Different instruction algorithms apply, depending on the basic life support experience of the caller, with compression-only CPR for untrained callers and conventional CPR (ratio 30:2) for trained callers. There is no first-responder programme in the Capital Region of Denmark. Ambulance personnel report OHCAs to the Danish Cardiac Arrest Registry and MCCU physicians register OHCAs in the MCCU database.

Data collection

We identified all OHCAs from the Danish Cardiac Arrest Registry and the MCCU database to ensure high catchment. Duplicates from the MCCU database were removed. Data were linked to the EMDC database via ambulance record number or a combination of the unique Danish personal identification number from the Danish Civil Registration System and the OHCA date [31]. Emergency call recordings were identified via the date and time of the emergency call in combination with the address. Survival data were retrieved from the Danish Civil Registration System.

OHCA patients in the Capital Region of Denmark from January 1, 2013 to December 31, 2013 were included in the study. Prior to the evaluation of emergency calls, we excluded OHCAs that were EMS-witnessed, unmatchable with the EMDC database, or had no corresponding emergency call. Following the evaluation of

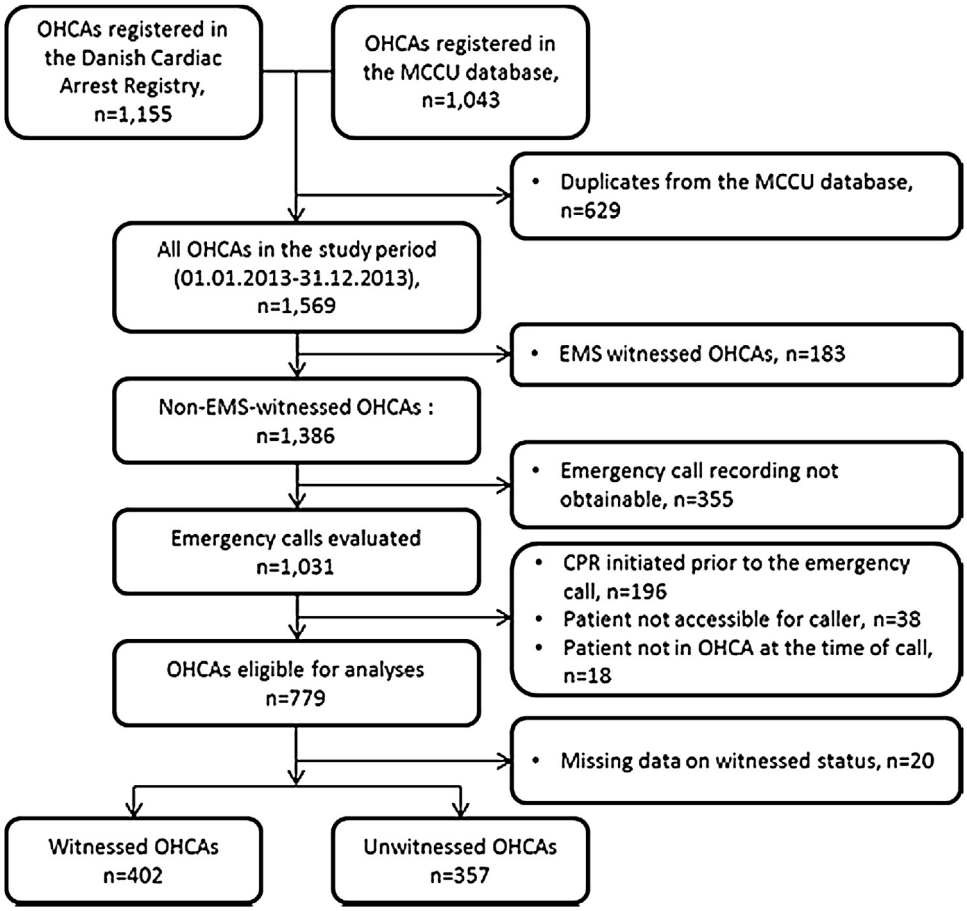

Fig. 1. Data Collection Process Flowchart describing the data collection process. CPR indicates cardiopulmonary resuscitation; EMS, emergency medical services; MCCU, Mobile Critical Care Unit; OHCA, out-of-hospital cardiac arrest.

emergency calls, we excluded OHCAs in which bystander CPR was initiated prior to the emergency call, the patient was obviously alive during the emergency call, or the caller could not access the patient (Fig. 1).

To evaluate the emergency call recordings, we developed and tested a case report form (CRF; Supplemental Table 1). To select variables for registration, 20 randomly chosen emergency calls of confirmed OHCA were discussed among a panel of researchers with OHCA and emergency call research experience. The panel selected and defined 13 variables and data collection was performed by two authors (SV and TPM). To test the CRF, inter-rater reliability between the two authors was evaluated by applying Cohen's kappa statistics to 100 randomly selected emergency calls of confirmed OHCA. Inter-rater reliability showed a variation in kappa values ranging from 0.18 to 0.95 (with kappa values ranging from 0.50 to 0.95 for 11 out of 13 of the variables). For the core variable "recognition of OHCA," we found a kappa value = 0.88 (95% confidence interval [CI]: 0.79–0.98). Two variables showed a kappa value of less than 0.50 ("Addressing abnormal breathing" and "Caller's relation to the patient"). These variables were further revised to ensure uniform registration. All emergency calls were divided between the two authors and the calls were evaluated using the revised CRF. During the evaluation of all emergency calls, differences in registration of the variable "abnormal breathing" between the two authors were seen. To ensure uniform registration of data, the definition of "abnormal breathing" was further revised, and all calls were evaluated again by one author (SV) for this variable only.

Age was divided into four groups: ≤59, 60–69, 70–79, or ≥80 years based on the age distribution in data. OHCA variables from the Danish Cardiac Arrest Registry and the MCCU database including location, witnessed status, bystander CPR, shockable rhythm, defibrillation by an AED, and ROSC were registered according to the Utstein 2004 guidelines [32]. Ambulance priority and EMS response time were registered in the EMDC database. Ambulance priority ranged from A to D, with A = "as fast as possible" and D = "scheduled transport" [29]. EMS response time was characterised as the time from ambulance dispatch to arrival at scene (vehicle stop).

Recognition of OHCA was defined as cases where the caller or dispatcher expressed the presence of OHCA, or the need for CPR or an AED. We determined from the emergency call recordings whether or not bystander CPR was initiated prior to the emergency call. For further definition of variables in the CRF, see Supplemental Table 1.

Date of death was extracted from the Danish Civil Registration System and 30-day survival was calculated.

Statistical analyses

Incidence rate of OHCA was calculated as number of OHCA in the 1-year study period divided with the population in the Capital Region of Copenhagen, assuming they all contributed with one person-year. Descriptive analysis was performed using frequency distributions (number, %), mean value, standard deviation, median value, and interquartile range (Q_1–Q_3). Fisher's exact test was used to analyse the association between OHCA recognition and categorical variables. Student's *t*-test was used to analyse the association between OHCA recognition and EMS response time. Due to a skewed distribution of patient age and EMS response time, these variables were logarithmically transformed prior to analysis, and the geometric mean was used for descriptive analysis.

Two multivariable logistic regression analyses were performed to analyse the association between OHCA recognition and bystander CPR, ROSC, and 30-day survival: (1) a sex- and age group-adjusted model; and (2) a fully-adjusted model (sex, age group, witnessed status, and number of bystanders). Potentially confounding factors were identified and plotted in causal diagrams to define which factors to include in the model (Supplemental Figs. 1 and 2). Both models were applied to all OHCAs and witnessed OHCAs only. Effect modification was evaluated in the analyses estimating the association between OHCA recognition and bystander CPR by including the two-way interactions between OHCA recognition and the caller's relation to the patient, number of bystanders, age of the patient, sex of the patient, and sex of the caller. Univariable logistic regression analyses were performed to identify patient-, setting-, and dispatcher-related predictors of OHCA recognition. Results were reported as odds ratios (OR) with 95% CIs and *p*-values when appropriate. A p-value < 0.05 was considered significant for all analyses.

Table 1
OHCA Characteristics for All OHCA Patients and Witnessed OHCA Patients Only.

	All OHCA Patients (n = 779)		Witnessed OHCA Patients (n = 402)	
		Missing		Missing
Patient characteristics				
Age, median (Q_1-Q_3)	72 (60–82)	43	73 (62–82)	25
Male, n (%)	465 (63.2)	43	241 (63.9)	25
Setting characteristics				
Location				
Residential, n (%)	570 (76.2)	31	270 (69.2)	12
Public, n (%)	178 (23.8)	31	120 (30.8)	12
Witnessed, n (%)	402 (53.0)	20	–	–
Bystander CPR, n (%)	427 (56.2)	19	231 (57.5)	0
Shockable rhythm, n (%)	142 (19.3)	42	106 (27.2)	13
Defibrillated by an AED, n (%)	13 (1.9)	85	11 (3.1)	42
Dispatcher characteristics				
Recognition, n (%)	534 (70.1)	17	243 (61.4)	6
Ambulance priority A, n (%)	745 (95.6)	0	385 (95.8)	0
Response time (mm:ss), mean[a] (95% CI)	06:02 (05:49–06:16)	24	06:10 (05:51–06:30)	14
Patient outcome				
ROSC, n (%)	217 (28.7)	24	167 (42.2)	6
30-day survival, n (%)	93 (12.6)	43	75 (19.9)	25

AED indicates automated external defibrillator; CI, confidence interval; CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; ROSC, return of spontaneous circulation; Q_1-Q_3, interquartile range.

[a] Geometric mean.

Table 2
Medical Dispatchers' Recognition of OHCA during Emergency Calls by Sex, Age, Witnessed Status, Location of OHCA, and Shockable/Non-shockable Rhythm.

Subgroup	All OHCA-patients, n = 779		
	Patients in Each Subgroup, n	Recognition, n (%)	Missing, n
Sex			
Male	454	323 (71.2)	60
Female	265	185 (69.8)	
Age group			
<60	168	121 (72.0)	60
60–69	156	123 (78.9)	
70–79	180	132 (73.3)	
≥80	215	132 (61.4)	
Witnessed			
Yes	396	243 (61.4)	35
No	348	280 (80.5)	
Location			
Public	174	116 (66.7)	45
Residential	560	400 (71.4)	
Rhythm			
Shockable	141	106 (75.2)	56
Non-shockable	582	400 (68.7)	

All abbreviations can be found in Table 1.

Approvals

The study was approved by the Danish Health Authority (3-3013-1289/1/), the Danish Data Protection Agency (2012-58-0004), and the regional ethics committee (15009536).

Results

We identified 1386 non-EMS-witnessed OHCAs (incidence of 79.2 OHCAs per 100,000 inhabitants per year); of these, 1031 call recordings were obtainable, and consequently extracted and evaluated. After evaluation, we excluded 252 OHCAs due to bystander CPR that was initiated prior to the emergency call, patients obviously alive during the emergency call, or patients not accessible to the caller, leaving 779 emergency calls eligible for analyses (Fig. 1).

Medical dispatchers recognised 70.1% (534) of OHCAs where bystander CPR was not initiated prior to the emergency call. Prior to EMS arrival, 56.2% (n = 427) of the patients received bystander CPR and 1.9% (n = 13) were defibrillated by an AED. Among all patients, 28.7% (n = 217) achieved ROSC and 12.6% (n = 93) were alive at 30 days (Table 1). For results on OHCA recognition among subgroups, see Table 2.

When OHCA was recognised, 97.2% (n = 518) received dispatcher-assisted CPR. When comparing recognised versus unrecognised OHCA, we found that recognised OHCA had significantly more "priority A" response (97.9% vs. 90.8%, p < 0.001) and bystander CPR (69.3% vs. 28.1%, p < 0.001), but no significant difference for ROSC (28.3% vs. 29.9%, p = 0.72) or 30-day survival (13.4% vs. 10.9%, p = 0.39). However, recognised cases showed a significantly higher proportion of ROSC (46.7% vs. 34.7%, p = 0.021) and 30-day survival (25.2% vs. 11.4%, p = 0.001) in witnessed OHCAs (Table 3).

Among all OHCA patients, the fully-adjusted logistic regression analysis showed that recognition of OHCA during emergency calls was significantly associated with bystander CPR (OR = 7.84, 95% CI: 5.10–12.05). However, recognition of OHCA was not associated with ROSC (OR = 1.23, 95% CI: 0.81–1.88) or 30-day survival (OR = 1.72, 95% CI: 0.95–3.12) among all OHCA patients. Among witnessed OHCAs only, the multivariable analysis demonstrated that recognition of OHCA during emergency calls was significantly associated with bystander CPR (OR = 5.36, 95% CI: 3.19–9.01), ROSC (OR = 1.86, 95% CI: 1.13–3.06), and 30-day survival (OR = 2.80, 95% CI: 1.58–4.96) (Fig. 2). No effect modification was identified as significant in the analysis evaluating the association between OHCA recognition and bystander CPR (p-value ≥ 0.07). The full multivariable models are provided as supplementary material (Supplemental Table 2).

Univariable logistic regression analyses identified the following predictors of OHCA recognition: addressing breathing (OR = 1.76, 95% CI: 1.17–2.66) and the caller being located by the patient's side (OR = 2.16, 95% CI: 1.46–3.19). By contrast, the odds of recognition were significantly lower when OHCA was witnessed (OR = 0.39, 95% CI: 0.28–0.54), the caller was a health care professional (OR = 0.68, 95% CI: 0.48–0.98), or the patient was older than 80 years of age (OR = 0.62, 95% CI: 0.40–0.95) (Fig. 3).

Discussion

The main finding of this comprehensive observational study is that OHCA recognition during emergency calls is significantly associated with a 5- to 8-fold increase in the odds of bystander CPR among all OHCA patients. Furthermore, OHCA recognition is significantly associated with a nearly 3-fold increase in the odds of 30-day survival among witnessed OHCA patients.

The positive association between recognition of OHCA during emergency calls and the provision of bystander CPR is most likely mediated by the delivery of dispatcher-assisted CPR instructions. Our study confirms that the medical dispatcher provided dispatcher-assisted CPR instructions to the bystander in nearly every case of recognised OHCA. Furthermore, two separate studies report that the provision of dispatcher-assisted CPR almost doubled the proportion of bystander CPR provided [19,20]. Taken together, these findings strongly suggest that recognising OHCA during emergency calls is an essential prerequisite for dispatcher-assisted CPR and, consequently, bystander CPR prior to EMS arrival in all OHCA patients.

The positive association between OHCA recognition, ROSC, and 30-day survival among witnessed OHCAs strongly indicates that the first link in the chain of survival can positively affect patient outcomes and potentially improve overall survival. This positive association is also significant in the fully adjusted analysis, suggesting that the results are not biased by the influence of confounding variables such as patient characteristics. The association was only observed in witnessed OHCAs, which makes sense given that life-saving initiatives (facilitated by the recognition of OHCA) might have almost no effect if the delay post-collapse exceeds approximately 15 min [5,6,33].

The association between OHCA recognition and 30-day survival is most likely mediated by the performance of bystander CPR and fast EMS response. Other studies have evaluated the association between recognition of OHCA and survival with contradicting results. Kuisma et al. examined bystander witnessed OHCAs with ventricular fibrillation of cardiac origin from 1997 to 2002 in Helsinki and found no difference in survival [27]. This study only included 373 patients and dispatcher-assisted CPR was only provided in 35.5% of recognised cases.

Berdowski et al. evaluated 285 emergency calls from 2004 and found that OHCA recognition significantly increased survival at three months from 5% to 14% [26]. In addition; they discovered that among unrecognised OHCAs, no dispatcher-assisted CPR was performed and ambulance dispatch was delayed by 0.94 min. Our study confirms the positive association between OHCA recognition and 30-day survival in a larger population, excluding OHCAs in which bystander CPR was performed prior to the emergency call; this exclusion ensures that focus remains on the clinically most rel-

Table 3
The Association between Recognition of OHCA during Emergency Calls and Dispatcher and Bystander Actions, as Well as Patient Outcome.

	All OHCA Patients (n = 779)				Witnessed OHCA Patients (n = 402)			
	Recognised[a] Yes (n = 534)	No (n = 228)	Missing, (n)	p-value	Recognised[a] Yes (n = 243)	No (n = 153)	Missing, (n)	p-value
Dispatcher actions								
Time to recognition (mm:ss), mean[b] (95% CI)	01:09 (01:05–01:13)	–	0	–	01:20 (01:12-01:28)	-	0	–
DA-CPR, n (%)	518 (97.2)	0 (0)	18	<0.001	236 (97.5)	0 (0)	7	<0.001
BLS competence addressed, n (%)	305 (57.6)	0 (0)	21	<0.001	142 (58.7)	0 (0)	7	<0.001
AED addressed, n (%)	63 (11.9)	0 (0)	20	<0.001	39 (16.1)	0 (0)	7	<0.001
Call continued till EMS arrival, n (%)	259 (49.4)	19 (8.5)	31	<0.001	131 (54.6)	13 (8.6)	11	<0.001
Response time (mm:ss), mean[b] (95% CI)	05:54 (05:40–06:08)	06:24 (05:52–06:57)	40	0.092	05:57 (05:35–06:19)	06:32 (05:55-07:13)	20	0.105
Response priority A, n (%)	523 (97.9)	207 (90.8)	17	<0.001	238 (97.9)	141 (92.2)	6	0.017
Bystander actions								
Bystander CPR, n (%)	363 (69.3)	62 (28.1)	34	<0.001	178 (73.3)	52 (34.0)	6	<0.001
Defibrillated by an AED, n (%)	9 (1.9)	4 (2.0)	100	1.0	7 (3.2)	4 (2.9)	48	1.0
Patient outcome								
ROSC, n (%)	147 (28.3)	66 (29.9)	39	0.723	112 (46.7)	55 (34.7)	12	0.021
30-day survival, n (%)	68 (13.4)	23 (10.9)	60	0.391	58 (25.2)	16 (11.4)	31	0.001

BLS indicates basic life support; DA-CPR, dispatcher-assisted cardiopulmonary resuscitation EMS, emergency medical services.
Response A: highest priority immediate response with lights and sirens; All other abbreviations can be found in Table 1.
[a] OHCAs with missing information regarding recognition were excluded from the analyses (see Table 1 for exact numbers).
[b] Geometric mean.

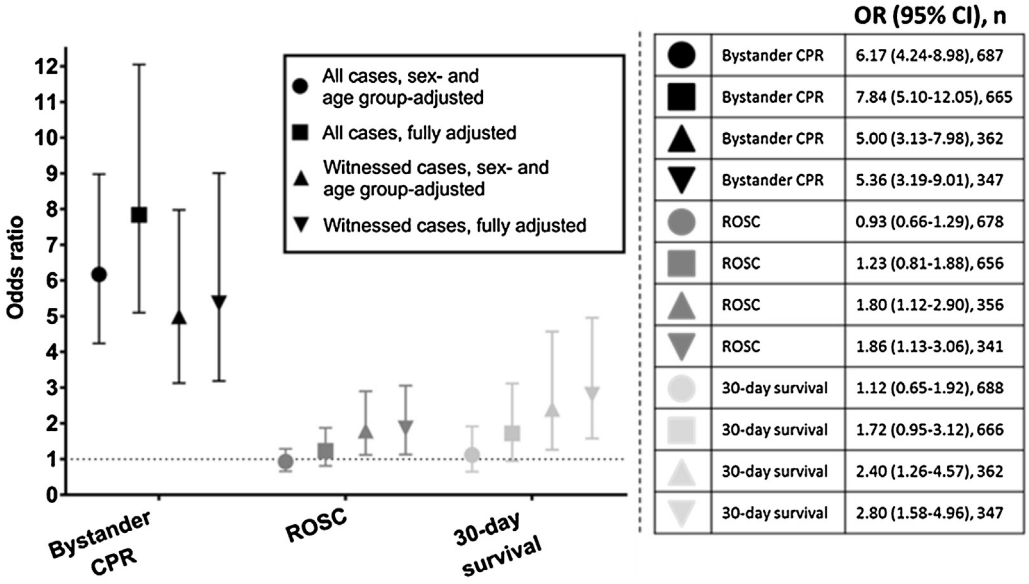

Fig. 2. Association between OHCA Recognition and Bystander CPR, ROSC, and 30-day Survival OR for the association between recognition of OHCA during emergency calls and bystander CPR, ROSC, and 30-day survival among all OHCA-patients and witnessed OHCA-patients only. Fully adjusted: Adjusted for sex, age group, and number of bystanders in both sets of analyses (all cases and witnessed cases only) as well as witnessed status in the analyses of all cases. CI indicates confidence interval; CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; OR, odds ratio; ROSC, return of spontaneous circulation.

evant cases where the impact of the medical dispatchers' efforts is largest and no life-saving actions have been initiated.

Our study reports recognition of 70.1%, similar to other studies with recognition ranging from 71% to 80%, however, none of them exclude OHCAs with bystander CPR initiated prior to the emergency call [7,26,34]. Among studies reporting OHCA recognition, the definition of study population and classification of recognised OHCA differ substantially, which challenges the comparison of recognition between our study and others.

We identified the caller being by the patient's side as a positive predictor of OHCA recognition. The reason for this may be that the caller's ability to assess the patient is important to ensure valid clinical information alongside continuous communication with the bystander throughout the emergency call. Furthermore, we identified that addressing breathing is a predictor of OHCA recognition. Breathing should be addressed in every emergency call [35]. Studies report that up to 40% of all OHCA patients show signs of agonal breathing; however, the interpretation of breathing patterns during emergency calls is difficult [26,36,37]. Mandatory breathing evaluations may be one way to increase agonal breathing recognition and could potentially improve survival [37]. Similar to another study we found that OHCA recognition during emergency calls was lower

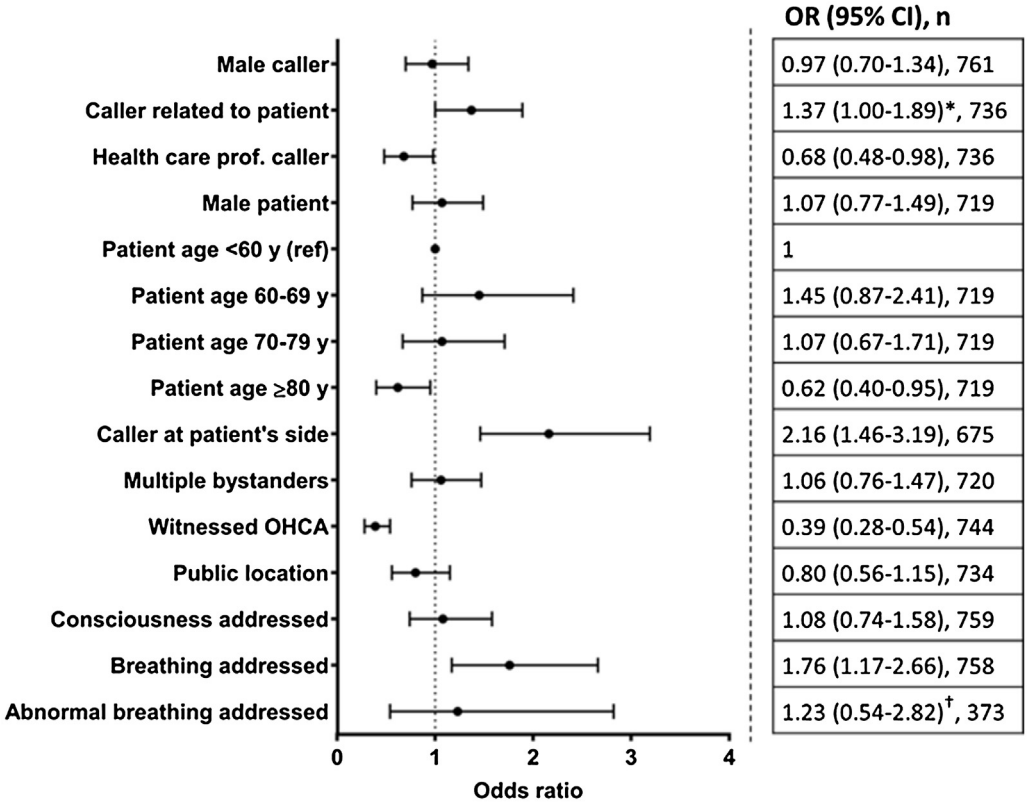

Fig. 3. Predictors of Recognition of OHCA OR for predictors of recognition of OHCA during emergency calls where bystander CPR is not initiated prior to the emergency call. *P-value = 0.0499 †The analysis on abnormal breathing was made on OHCAs where some kind of breathing pattern was described during the call CI indicates confidence interval; OHCA, out-of-hospital cardiac arrest; OR, odds ratio.

in witnessed OHCAs [7]; this could be explained by the presence of agonal breathing shortly after collapse [37]. Agonal breathing is present in 55% of witnessed OHCAs and may delay recognition [37,38].

Future perspectives

To improve OHCA recognition, mandatory and systematic questioning is important. The "No, No, then Go" concept (No = patient not conscious; No = patient not breathing normally; Go = dispatch high priority ambulance and start dispatcher-assisted CPR instructions), recommended by the American Heart Association and the Global Resuscitation Alliance, is a structured 2-question approach that is simple to apply [25,35]. This concept ensures that every call is evaluated as an OHCA until proven otherwise, being mindful of the fact that OHCA only represents 1% of all emergency calls.

To further improve the effect of OHCA recognition, future efforts should focus on the quality of dispatcher-assisted CPR provided during recognised OHCA. Dispatcher-assisted CPR has been proven to positively affect the provision of bystander CPR; increased quality of dispatcher-assisted CPR could increase the provision of bystander CPR even further, as well as the quality of bystander CPR – both of which will result in increased patient survival [3,9–12,21,22].

The great potential of defibrillation by AEDs has been demonstrated in several studies [15,16]. OHCA recognition is key to the initiation of public access defibrillation programmes activated from the dispatch centre. In Denmark and Sweden, interactive maps showing the position and availability of AEDs have been implemented at the dispatch centre. Nonetheless, a recent study from Sweden revealed that medical dispatchers only referred bystanders to an AED in 4.3% of reported OHCAs that occurred near an available AED [39]; this finding suggests that OHCA recognition is essential for the utilization of publicly accessible AEDs.

One initiative that may improve both the recognition and quality of dispatcher-assisted CPR and AED referral would be for OHCA calls to be audited by fellow dispatchers or medical directors for learning purposes as suggested by the American Heart Association and Global Resuscitation Alliance [25,35]. No studies have investigated this particular intervention alone, but several studies have reported improvements in patient outcomes after larger structural changes, including auditing OHCA emergency calls [21,40].

Limitations

First, the main limitation is that this was an observational study; as a result, the relationship between variables can only be interpreted as associations and not direct causality. Second, we excluded 355 OHCA patients for whom no emergency call recordings were available. This could cause selection-bias, which would either falsely increase or decrease the estimates in this study; however, baseline characteristics for this excluded group were similar to the included OHCA patients, except for the proportion of OHCA in public locations, which is slightly higher in the excluded patients (Supplemental Table 2). We have no reason to suspect any systematic causes for not obtaining these calls, which could have introduced bias into the selection of OHCA patients.

Conclusions

Recognition of OHCA during emergency calls is positively associated with bystander CPR in all OHCAs, as well as ROSC and 30-day survival in witnessed OHCAs. Several factors, including direct access to the patient and addressing breathing, were iden-

tified as predictors of OHCA recognition. Increased efforts to improve OHCA recognition during emergency calls could potentially increase patient survival after OHCA.

Conflict of interest

None

Aknowledgements

This study was funded by "TrygFonden" (ID: 113516) and centre-support from the Laerdal Foundation. The supporting organisations had no influence on the design or the conduct of this study; collection, analysis, or interpretation of the data; preparations or approval of the manuscript; or the final decision to submit for publication.

The authors would like to acknowledge the editing assistance provided by Erin Hanley, MS.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.resuscitation.2017.04.006.

References

[1]. Sasson C, Rogers MA, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. Circ Cardiovasc Qual Outcomes 2010;3:63–81.
[2]. Gräsner J-T, Lefering R, Koster RW, et al. EuReCa ONE—27 Nations, ONE Europe, ONE Registry: a prospective one month analysis of out-of-hospital cardiac arrest outcomes in 27 countries in Europe. Resuscitation 2016;105:188–95.
[3]. Wissenberg M, Lippert FK, Folke F, et al. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. JAMA 2013;310:1377–84.
[4]. Strömsöe A, Svensson L, Axelsson ÅB, et al. Improved outcome in Sweden after out-of-hospital cardiac arrest and possible association with improvements in every link in the chain of survival. Eur Heart J 2015;36:863–71.
[5]. Larsen MP, Eisenberg MS, Cummins RO, Hallstrom AP. Predicting survival from out-of-hospital cardiac arrest: a graphic model. Ann Emerg Med 1993;22:1652–8.
[6]. Holmberg M, Holmberg S, Herlitz J. Incidence, duration and survival of ventricular fibrillation in out-of-hospital cardiac arrest patients in Sweden. Resuscitation 2000;44:7–17.
[7]. Lewis M, Stubbs BA, Eisenberg MS. Dispatcher-assisted cardiopulmonary resuscitation: time to identify cardiac arrest and deliver chest compression instructions. Circulation 2013;128:1522–30.
[8]. Zijlstra JA, Stieglis R, Riedijk F, Smeekes M, van der Worp WE, Koster RW. Local lay rescuers with AEDs, alerted by text messages, contribute to early defibrillation in a Dutch out-of-hospital cardiac arrest dispatch system. Resuscitation 2014;85:1444–9.
[9]. Stiell IG, Brown SP, Nichol G, et al. What is the optimal chest compression depth during out-of-hospital cardiac arrest resuscitation of adult patients? Circulation 2014;130:1962–70.
[10]. Wik L, Steen PA, Bircher NG. Quality of bystander cardiopulmonary resuscitation influences outcome after prehospital cardiac arrest. Resuscitation 1994;28:195–203.
[11]. Gallagher EJ, Lombardi G, Gennis P. Effectiveness of bystander cardiopulmonary resuscitation and survival following out-of-hospital cardiac arrest. JAMA 1995;274:1922–5.
[12]. Hasselqvist-Ax I, Riva G, Herlitz J, et al. Early cardiopulmonary resuscitation in out-of-hospital cardiac arrest. N Engl J Med 2015;372:2307–15.
[13]. Ringh M, Jonsson M, Nordberg P, et al. Survival after public access defibrillation in stockholm, Sweden-A striking success. Resuscitation 2015;91:1–7.
[14]. Berdowski J, Blom MT, Bardai A, Tan HL, Tijssen JGP, Koster RW. Impact of onsite or dispatched automated external defibrillator use on survival after out-of-hospital cardiac arrest. Circulation 2011;124:2225–32.
[15]. Valenzuela TD, Roe DJ, Nichol G, Clark LL, Spaite DW, Hardman RG. Outcomes of rapid defibrillation by security officers after cardiac arrest in casinos. N Engl J Med 2000;343:1206–9.
[16]. Blom MT, Beesems SG, Homma PCM, et al. Improved survival after out-of-hospital cardiac arrest and use of automated external defibrillators. Circulation 2014;130:1868–75.
[17]. Ringh M, Rosenqvist M, Hollenberg J, et al. Mobile-phone dispatch of laypersons for CPR in out-of-hospital cardiac arrest. N Engl J Med 2015;372:2316–25.
[18]. Hansen CM, Lippert FK, Wissenberg M, et al. Temporal trends in coverage of historical cardiac arrests using a volunteer-based network of automated external defibrillators accessible to laypersons and emergency dispatch centers. Circulation 2014;130:1859–67.
[19]. Culley LL, Clark JJ, Eisenberg MS, Larsen MP. Dispatcher-assisted telephone CPR: common delays and time standards for delivery. Ann Emerg Med 1991;20:362–6.
[20]. Vaillancourt C, Verma A, Trickett J, et al. Evaluating the effectiveness of dispatch-assisted cardiopulmonary resuscitation instructions. Acad Emerg Med 2007;14:877–83.
[21]. Tanaka Y, Taniguchi J, Wato Y, Yoshida Y, Inaba H. The continuous quality improvement project for telephone-assisted instruction of cardiopulmonary resuscitation increased the incidence of bystander CPR and improved the outcomes of out-of-hospital cardiac arrests. Resuscitation 2012;83:1235–41.
[22]. Rea TD, Eisenberg MS, Culley LL, Becker L. Dispatcher-assisted cardiopulmonary resuscitation and survival in cardiac arrest. Circulation 2001;104:2513–6.
[23]. Monsieurs KG, Nolan JP, Bossaert LL, et al. European resuscitation council guidelines for resuscitation 2015: section 1. Executive summary. Resuscitation 2015;95:1–80.
[24]. Neumar RW, Shuster M, Callaway CW, et al. Part 1: executive summary 2015 american heart association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation 2015;132:S315–67.
[25]. Eisenberg M, Lippert FK, Shin SD, et al. Improving survival from out-of-hospital cardiac arrest: a call to establish a global resuscitation alliance. Seattle, WA, USA: Resuscitation Academy; 2017 (Accessed August 12, 2016, at http://www.resuscitationacademy.org/wp-content/uploads/2016/03/A-Call-to-Establish-a-Global-Resuscitation-Alliance1.pdf).
[26]. Berdowski J, Beekhuis F, Zwinderman AH, Tijssen JG, Koster RW. Importance of the first link: description and recognition of an out-of-hospital cardiac arrest in an emergency call. Circulation 2009;119:2096–102.
[27]. Kuisma M, Boyd J, Väyrynen T, Repo J, Nousila-Wiik M, Holmström P. Emergency call processing and survival from out-of-hospital ventricular fibrillation. Resuscitation 2005;67:89–93.
[28]. StatBank Denmark. Statistics Denmark; 2017 (Accessed August 12, 2016, at http://www.statbank.dk/statbank5a/default.asp?w=1920).
[29]. Møller TP, Ersbøll AK, Tolstrup JS, et al. Why and when citizens call for emergency help: an observational study of 211,193 medical emergency calls. Scand J Trauma Resusc Emerg Med 2015;23:88.
[30]. Andersen MS, Johnsen SP, Sørensen JN, Jepsen SB, Hansen JB, Christensen EF. Implementing a nationwide criteria-based emergency medical dispatch system: a register-based follow-up study. Scand J Trauma Resusc Emerg Med 2013;21:53.
[31]. Pedersen CB. The danish civil registration system. Scand J Public Health 2011;39:22–5.
[32]. Jacobs I, Nadkarni V, Bahr J, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update and simplification of the Utstein templates for resuscitation registries: a statement for healthcare professionals from a task force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian Resuscitation Council, New Zealand Resuscitation Council, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Councils of Southern Africa). Resuscitation 2004;63:233–49.
[33]. Reynolds JC, Frisch A, Rittenberger JC, Callaway CW. Duration of resuscitation efforts and functional outcome after out-of-hospital cardiac arrest: when should we change to novel therapies? Circulation 2013;128:2488–94.
[34]. Dami F, Heymann E, Pasquier M, Fuchs V, Carron P-N, Hugli O. Time to identify cardiac arrest and provide dispatch-assisted cardio-pulmonary resuscitation in a criteria-based dispatch system. Resuscitation 2015;97:27–33.
[35]. Lerner EB, Rea TD, Bobrow BJ, et al. Emergency medical service dispatch cardiopulmonary resuscitation prearrival instructions to improve survival from out-of-hospital cardiac arrest a scientific statement from the American Heart Association. Circulation 2012;125:648–55.
[36]. Travers S, Jost D, Gillard Y, et al. Out-of-hospital cardiac arrest phone detection: those who most need chest compressions are the most difficult to recognize. Resuscitation 2014;85:1720–5.
[37]. Bobrow BJ, Zuercher M, Ewy GA, et al. Gasping during cardiac arrest in humans is frequent and associated with improved survival. Circulation 2008;118:2550–4.
[38]. Clark JJ, Larsen MP, Culley LL, Graves JR, Eisenberg MS. Incidence of agonal respirations in sudden cardiac arrest. Ann Emerg Med 1992;21:1464–7.
[39]. Fredman D, Svensson L, Ban Y, et al. Expanding the first link in the chain of survival – experiences from dispatcher referral of callers to AED locations. Resuscitation 2016:30120–4, http://dx.doi.org/10.1016/j.resuscitation.2016.06.022, pii: S0300-9572(16). [Epub ahead of print].
[40]. Harjanto S, Na MXB, Hao Y, et al. A before-after interventional trial of dispatcher-assisted cardio-pulmonary resuscitation for out-of-hospital cardiac arrests in Singapore. Resuscitation 2016;102:85–93.